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SUBJECT: APPROXIMATING THE 95TH PERCENTILE AND THE 90% CONFIDENCE LIMIT FOR EXPOSURE ESTIMATES FROM THE PESTICIDE HANDLERS EXPOSURE DATABASE (PHED V1.1)

The Worker Health and Safety Branch has recently established a standard practice of using these statistical estimates of exposure:

1. For short-term (up to 7 days duration) exposure, the estimated 95th percentile of absorbed daily dosage (ADD) will be used;

2. For any exposures of longer than 7-day duration, the 90% upper confidence limit on the arithmetic mean of absorbed daily dosage (ADD) will be used.

The *Draft Interim Guidance for the Preparation of Human Pesticide Exposure Assessment Documents* (Exposure Assessment and Mitigation Group (EAMG), 2001) gives methods for calculating the 95th percentile and the 90% confidence limit from a sample of data. Both calculations require the standard deviation of ADD for total (i.e., whole-body) dermal exposure.

When surrogate data from the Pesticide Handlers Exposure Database (PHED V1.1) are used to derive exposure estimates, the standard deviation is not available. A method is needed for approximating the percentile and confidence limit because the PHED summary output does not give sufficient information to calculate the exact values. PHED gives only the means and coefficients of variation per body region. Because the sample sizes per body region differ, and because the correlation structure among body regions is unknown, the variance of total body exposure, and therefore the percentiles and confidence limits, cannot be calculated. This memorandum describes a method for approximating the 95th percentile and the 90 percent upper confidence limit on the mean exposure in a PHED subset.

The following assumptions are made:
1) Total dermal exposure is lognormally distributed across persons.
2) Total dermal exposure has a coefficient of variation (CV) of 100 percent.

A CV of 100% is in the range of CVs seen for individual bodyparts in PHED subsets. However, this assumption is currently under review. The value of 100% could change as a result of the

review, which would result in a change in numeric values, but not in the basic method of approximating the percentile and confidence limit.

95th percentile

Using CV $= \sqrt{\exp\{\sigma^2\} - 1}$ (Crow and Shimizu, 1988), it can be seen that for any lognormal distribution with a CV of 100%, the standard deviation of the corresponding normal distribution, σ, is 0.83255. Further, for given σ, the ratio of any percentile *q* to the arithmetic mean, λ, is constant:

Percentile $q = \exp\{\mu + Z_q\sigma\}$.

$\lambda = \exp\{\mu + \frac{1}{2}\sigma^2\}$.

(Percentile *q*) / λ = $\exp\{Z_q\sigma - \frac{1}{2}\sigma^2\}$, a constant.

If λ and σ are known, therefore, the percentile can be calculated as $\lambda \times \exp\{Z_q\sigma - \frac{1}{2}\sigma^2\}$.

The proposed approximation substitutes the sample mean for λ, the value 0.83255 for σ, and the value of Student's $t_{(.95,\, n)}$ for Z_q. Apart from using an assumed, rather than an estimated value of s, this substitution produces the maximum likelihood estimate (MLE) of percentile *q,* $\exp\{\overline{X} + t_{(q;n)}s\}$. Some error is introduced by assuming a CV, in addition to the error due to the fact that the MLE is a biased estimator.

The ratios $\exp\{t_{(.95;n)}\sigma - \frac{1}{2}\sigma^2\}$ were calculated for several sample sizes and are given in Table 1.

Table 1. 95th percentile as multiple of arithmetic mean [a] (CV of 100% assumed).

n	Ratio of 95th %ile to mean	n	Ratio of 95th %ile to mean
100	2.8	20	3.0
75	2.8	18	3.0
60	2.8	15	3.1
50	2.9	12	3.2
40	2.9	10	3.3
35	2.9	8	3.0
30	2.9	5	4.0
25	2.9	4	5.0

[a] The 95th percentile is approximated by multiplying the arithmetic mean of total exposure by the multiple corresponding to the sample size equal to or smaller than the smallest number of observations for any body part.

In order to avoid giving the impression of greater numeric accuracy than this method can really provide, these multipliers have been rounded and grouped into the categories that appear in the exposure assessment guidance document (EAMG, 2001, Table 9) and in Table 2 below.

Table 2. Approximate 95*th* percentile as multiple of arithmetic mean total exposure from PHED.

n	Multiplier
> 15	3
5-14	4
< 5	5

90% upper confidence limit for mean

It can also be shown that the ratio of the value of a given confidence limit to the mean is constant for fixed σ. Exact upper 90% confidence limits were calculated for various values of *n*, using the method and computer program of Land (1975; Land *et al.*, 1987) and assuming a CV of 100%. Table 3 gives the ratios of confidence limit to mean by sample size.

Table 3. 90% upper confidence limit on mean as multiple of arithmetic mean [a] (CV of 100% assumed).

n	Ratio of 90% CL to mean	n	Ratio of 90% CL to mean
100	1.1	20	1.4
75	1.2	18	1.4
60	1.2	15	1.5
50	1.2	12	1.6
40	1.2	10	1.7
35	1.3	8	1.9
30	1.3	5	2.9
25	1.3	4	4.5

[a] The 90% UCL is approximated by multiplying the arithmetic mean of total exposure by the multiple corresponding to the sample size equal to or smaller than the smallest number of observations for any body part.

It may appear incorrect that the upper bound on the mean is almost as great as the 95th percentile for *n* of 4. The reason for this is that the confidence limit reflects uncertainty about the mean, while the percentile estimate is simply a point estimate and does not reflect uncertainty. The extremely high confidence limits for small *n* reflect the fact that the mean is very poorly estimated in such small samples. In fact, the percentile is even more poorly estimated in small samples, but this uncertainty is not reflected in the point estimates.

As for the 95th percentile approximation, these multipliers have been rounded and grouped into the categories that appear in the exposure assessment guidance document (EAMG, 2001, Table 10) and in Table 4 below.

Table 4. Approximate upper 90% confidence limit on the mean as a multiple of arithmetic mean total exposure from PHED.

n	Multiplier
> 20	1.3
10-19	1.5
7-9	2
5-6	3
< 5	4.5

References

Crow, E. L. and K. Shimizu (1988). Lognormal Distributions: Theory and Applications. New York, Marcel Dekker, Inc.

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PHED V1.1. Pesticide Handlers Exposure Database, Version 1.1. Prepared for the PHED Task Force: Health Canada, U.S. EPA and the American Crop Protection Association, by Versar, Inc., Springfield, VA.